PURDUE UNIVERSITY

Agricultural Experiment Station

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Fig. 1. An ear-to-row test showing a diseased row between two healthy ones, planted from a good looking ear which germinated 100 per cent. The yields of fields throughout the Corn Belt are reduced by using seed from ears that are infested or weakened by harmful organisms

SELECTION OF DISEASE-FREE SEED CORN

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SUMMARY

Indiana corn yields are greatly reduced by hitherto little understood disease-producing organisms.

The planting of seed infested with these organisms is, in a great measure, responsible for missing hills, slow-growing stalks, barren stalks, down-stalks, nubbins, early blighting of plants in the field with the large reduction in yield which these conditions bring about.

The same organism which causes scab of wheat also causes rot of the stalks, ears, and ear-shanks of corn plants. Wheat planted in fields of diseased corn has more scab than occurs when the corn fields are free from scab-producing organism.

The ear-to-row method is recommended for studying the quality and value of seed ears. The selection of seed ears from disease-free stalks is recommended and explained.

By a careful study of germinating seedlings it is possible to discard from seed stock ears carrying disease-producing organisms. The bulletin explains how this may be done.

The type of germinator which serves best for this method of testing seed corn is also described and illustrated. Its use is recommended to all farmers who are interested in corn improvement and especially to seed corn breeders.

These facts had in a large measure been developed by investigations carried on by the authors during the past five years, and in 1917, this work was organized as an Experiment Station project.

SELECTION OF DISEASE-FREE SEED CORN[1]

GEORGE N. HOFFER J. R. HOLBERT

Many fields of corn in the Corn Belt states do not give the yields which their fertility and the attention given them in cultivation would justify. Considerable care may be used in selecting seed for planting, but too many missing hills and slow-growing stalks result. This has often been attributed to injuries from birds, root insects, and rodents, but recent studies on these troubles that have been made by Purdue University Agricultural Experiment Station in cooperation with the Office of Cereal Investigations, United States Department of Agriculture, show that while these injuries are important, there are other definite, harmful organisms which are responsible for disappointing stands and unprofitable yields.

When careful studies are made on seed ears, even those ears of high score card value, to determine their field performances by planting them by the ear-to-row method, it is apparent at once that some ears have high yielding ability, while others are of low power. The yield obtained in any field of corn is always the average of the yielding capacities of all the ears planted. The low yielding ears are most often those which had been taken from weakened parent stalks. This weakness may be due to the results of freezing or to injuries to the stalks caused by harmful organisms, such as fungi and bacteria.

EFFECTS OF PARASITIC ORGANISMS ON CORN PLANTS

The effects of certain fungi on the corn plants may be very marked. They may be observed readily in the form of smut, rust, broken ear shanks, broken stalks, and down-stalks which may be distributed irregularly through a field. Other harmful organisms may cause less striking effects on the plants. Inconspicuous rotting of the stalks, of the ears, and of the roots, may take place with no apparent injury. The ears, however, which are borne on such diseased plants are weakened. Perhaps the weakness is not enough to show decreased vitality on the germinator, but is evident in the field performance of the seed when taken from the ear and planted the following season.

The kernels from ears borne on diseased plants will have seedling characteristics which can be noted usually on the germinator. These seedling features and certain physical characters of the seed serve as a basis for discarding for seed purposes the incompletely matured ears formed on diseased stalks, since it has been shown that one effect of the rot-producing organisms may be to delay maturity. In contrast with such ears, those kernels from disease-free mother plants do not show the

[1] The work reported in this publication is the result of cooperation between the Bureau of Plant Industry of the United States Department of Agriculture, and the Purdue University Agricultural Experiment Station

Fig. 2. Two infested seedlings which died soon after germinating. This blighting causes poor stands

abnormal conditions referred to above, and always give good germination on the germinator, provided no injury, such as freezing, has occurred.

The difference between infested and disease-free seed is very striking in fields where seedlings die early and where the plants blight while young. Some plants may remain stunted during the entire growing season. Fig. 2 shows some plants which died early. Ordinarily these plants are not noticed before the first cultivation. At this time, however, plants as shown in Fig. 3 may be found. The roots and bases of such young stunted stalks are rotted, as shown in Fig. 4.

For permanent corn improvement, only ears from disease-free stalks should be used for seed purposes. Improvement by this means, at first thought, may appear difficult to accomplish. There are two methods of selection of good seed ears, both of which, from the present state of knowledge, should be followed to insure freedom from disease.

1. Mature ears on disease-free stalks should be selected for planting. It is assumed that the variety of corn is one which is adapted to the soil and climatic conditions of the locality where it is grown and that it will mature in a normal season. Ears should never be selected from smutted stalks, or from stalks which are rotted or whose roots are rotted. Neither should ears be selected which have rotted, broken shanks as noted in Fig. 8. Many root-rotted plants die prematurely. The rotting of the stalk can be observed by cutting down through the plant and splitting it open. If the inner portion of the stalk, especially at the lower nodes or "joints," at the base of the stalk, shows a brown discoloration, the presence of a harmful organism in the plant is indicated. *A mature ear on a living green stalk is always best for seed purposes.*

Fig. 3. An infected seedling is indicated by early stunting. A barren stalk is usually the result

Fig. 4. A stunted stalk cut lengthwise through the base to show the rot resulting from a primary infection

2. A more critical study of the results of the germination test can be made than has been the habit in the past. It has been found that ears may have perfect germination and yet give low yields in the field; such ears have an unusual susceptibility to rot-causing organisms on the germinator. The seedlings from such ears may develop molds upon them and if they are cut through with a sharp knife at the time the normal seedlings are three or four inches in height, the rot will be noticed developing in the embryos of infected seedlings. This infection caused by harmful organisms, actually upon or within the seed-kernels, is called *primary infection. This early rotting of the seedling, the result of primary infection, is a germination characteristic by which the infested weak ears may be discarded before planting.*

Ears from diseased stalks may have kernels bearing harmful molds and bacteria in a relatively inconspicuous manner. The kernels may germinate, but at germination time, the young seedlings may be invaded readily because of this close relation. Then again, some ears may be free of any harmful organisms, but having been formed on a diseased parent-stalk, the seedlings growing from these ears are less resistant to infection and may, therefore, become infected readily on the germinator and in the field. Conspicuously moldy ears should never be considered for seed purposes.

In contrast with these infested ears are the ears from disease-free plants. The seedlings that develop from kernels on such ears do not show the rotting of the embryo before the plants are three or four inches in height. Figs. 14, 17. In other words, *primary infection does not occur in the seedlings from ears borne on disease-free stalks that are not otherwise injured.*

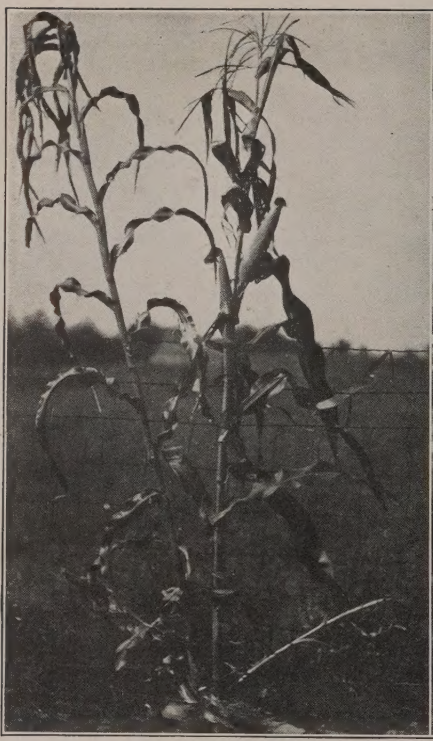


Fig. 5. A barren, a normal, and a stunted stalk in the same hill resulting from planting two infested seeds with a healthy one

Fig. 6. Do not select seed ears from smutted stalks

In the field, primary infections are very common in the plants from weakened and infested seed, Figs. 2 and 3. If the seeds are not weakened or infested with harmful organisms, the seedlings and plants will make good progress in growth in the field, providing weather and soil conditions are favorable.

The infected seedlings are slower growing, and depending upon their ability to overcome the effects of the organisms causing this primary infection, they may struggle along during the growing season and are not likely to produce good mature ears. The plants may be permanently stunted, and such plants are very common, or they may be only nubbin-bearing stalks.

It is this primary infection of seedlings in the field through the use of infested seed which is causing considerable losses to corn growers.

During the latter part of the growing season, *secondary infections* occur. These infections are caused by organisms which live in the soil on the remnants of a preceding crop, or which have been carried into the

Fig. 7. A prematurely dead stalk with rotted base. Note healthy adjacent stalk

soil on the infested seed which was used for planting. The same organisms which cause primary infections may also cause the secondary rotting of the roots. It is thus emphasized that infested seed may be responsible for both primary and secondary troubles in the same plants. The importance of planting disease-free seed is therefore apparent.

WHEAT SCAB RELATION

Another phase of the problem, and one which adds greater emphasis to the desirability of having disease-free corn fields, is the fact that the same organism which causes scab of wheat also causes a rot of the stalks and ear-shanks of corn plants. Wheat planted in diseased corn fields has more scab in it than when the corn fields are free of the scab-causing organism, or when it is planted following other crops. This intercrop relation is one of the most important problems of a pathological nature connected with the growing of these crops, especially so where winter wheat is planted in standing corn. The profitable control of wheat scab may be involved in the growing of disease-free corn, or in planting wheat on corn land providing all of the fodder will have been removed completely during the fall or winter.

METHOD OF CORRELATING GERMINATOR RESULTS WITH FIELD PERFORMANCE OF THE SEED EARS

The best way to study the field performance of seed ears is by the ear-to-row plot method. Germinator tests are first made on a number of the kernels, at least 30, taken from various parts of the ears to be studied. Enough of the ear is shelled to plant a row of 75 or 100 hills in length in the field. These rows are kept under close observation during the growing season. The various phenomena referred to in this bulletin may then be observed and the effects of the harmful organisms on the corn plants noted.

Fig. 11 shows how the results of an ear-to-row plot can be demonstrated at a field meeting. Note that the hard corn was placed in the front pile, the remnant ear was preserved in a tin can, the soft corn was placed in the back pile, and a 25-pound sample was bagged for moisture determination.

Fig. 1 shows how striking the effects of the root-rots may appear in certain rows. The row of "down stalks" was bordered by two rows of standing corn. The value of the ear-to-row method of study of the dis-

Fig. 8. Ears on broken shanks should not be used for seed

Fig. 9. Ears on broken shanks are frequently rotted

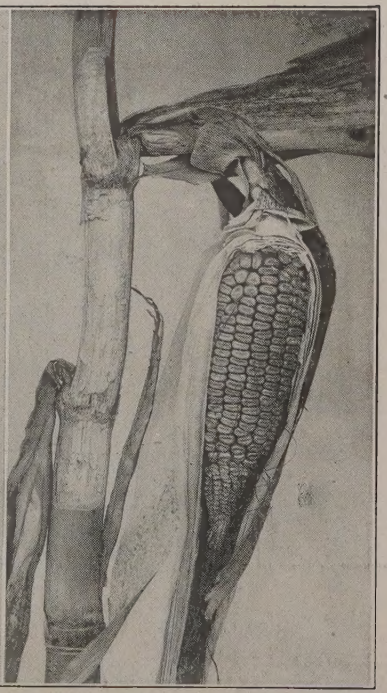


Fig. 10. Rotted stalks and shanks are responsible for many nubbins

Fig. 11. A well matured ear on a healthy shank is best for seed

eases of corn is that there is strikingly represented in the lives of the infested plants the phenomena which are so common in the ordinary fields of corn. All gradations of injuries may be noted.

For *seed corn* purposes no infested and weakened ears should be planted. These can be detected and discarded before planting.

THE GERMINATOR TEST

The testing of seed corn on germinators has already proved its worth. Bad ears are readily indicated in all types of germinators when dead kernels are found during the test. The method of interpretation of the germinator results recommended in this bulletin is applicable to all types of germinators in use, but is practiced most easily on the type of germinator recommended.

If the seedlings are infected on the germinator and show rotting of the embryo parts before the plants are three inches in height, as shown in Figs. 15 and 17, the ears from which the kernels were taken will show weaknesses in their field performances according to experimental results obtained to date.

The convenience with which these readings may be made is a matter of much importance where large numbers of ears are to be tested.

The rag-doll tester and the sand-box may be used but in as much as it is necessary to pull up the plants for examination, the former is the more convenient. But while the rag-doll is usable and fairly satisfactory for this method of interpretation of the seed corn test, the type of germinator where the seedlings can be observed as a whole, and the readings made directly, is the more desirable.

Fig. 12. A profitable hill of healthy stalks planted from disease-free ears

The type of germinator suggested involves the use of a limestone-sawdust base to supply the moisture for the germinating seeds. The germinator is very easily made and requires very little attention during the germination test. It is recommended to all farmers who are interested in corn improvement and especially so to those who breed corn on a large scale.

The germinator requires more effort to prepare, as well as more space, than the ones commonly used, but the advantage derived in being able to select disease-free ears commends it for this purpose.

The germinator is shown in Figs. 18, 19, and 20, and consists of a frame support on which there is a wire screen. This frame and screen holds about a two-inch layer of sawdust mixed with about one-fourth of its weight of ground limestone. The purpose of the limestone is to keep the sawdust sweet and to prevent the effects on the germinating seedlings of the injurious substances which develop in wet sawdust.

A sheet of heavy muslin that had been placed previously in boiling water to remove the starch is spread over this limestone-sawdust layer. The kernels of corn are placed on this muslin which may be marked in various ways to indicate the position of each of the ears tested, and the

Fig. 13. An ear-to-row test plot on harvest day. Note the hard corn, remnant ear box, soft corn and bag for moisture sample. This is the best method of determining high yielding, disease-free strains of corn varieties in each locality

seeds are then covered by another similarly treated sheet of muslin. The germinator and the sawdust-limestone substratum are then wet down with water, and to prevent rapid drying out are covered with gunny-sacks or heavy cloths for at least two days. When the corn germinates, these heavier cloths should be removed and the seedlings should be covered with the heavy muslin only. The germinator should be wet down thoroughly twice each day while in use. After the seedlings have grown to a height of three or four inches, they are ready for observation.

Those seedlings which have rotted embryos and stalks (Figs. 15 and 16), indicate the ears to be discarded for seed purposes. By reading the germinator on the basis of these rotted seedlings, and eliminating all of the ears which show this rot on the germinator, the primary infections which would otherwise occur in the field from seed from such ears and which would considerably reduce the yield in the field, can be prevented.

The harmful organisms referred to in this bulletin are species of Gibberella, Fusarium, Verticillium, Rhizopus and Pseudomonas. They will be described in a Technical Bulletin to be published in the near future.

Fig. 14. A good vigorous type of seedling. Note the early development of lateral rootlets

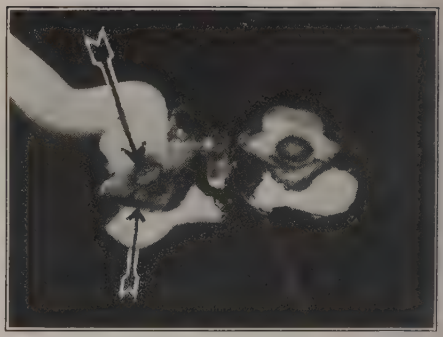


Fig. 15. An enlarged section through an infected seedling. The arrows point to the rotted tissue

Fig. 16. An infected seedling cut open to show the first stages in the development of rot. Contrast this with Figure 17

Fig. 17. A normal three-inch seedling cut through the embryo portion and laid open. Note the healthy condition of the germ

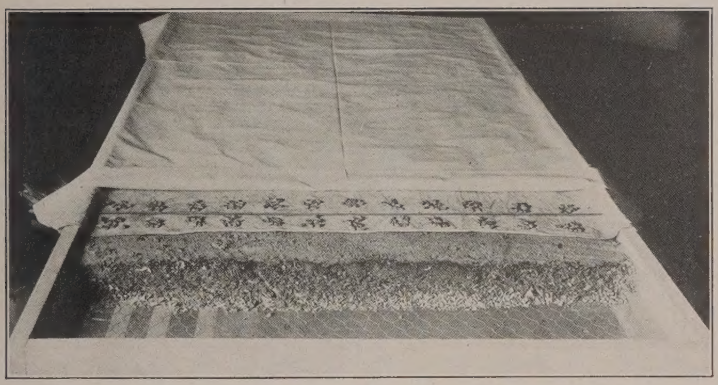


Fig. 18. A desirable type of germinator. Note layer of sawdust and limestone on the wire screen support

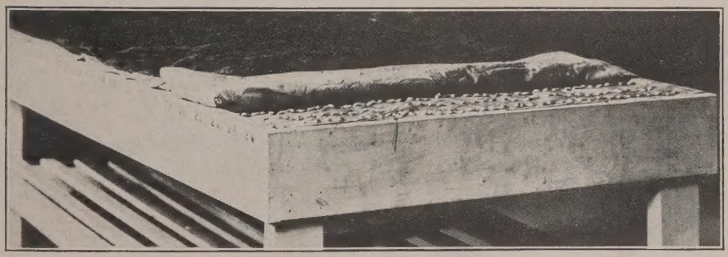


Fig. 19. Kernels in position on damp cloth ready to start test. Heavy cloths are placed on germinator for three days

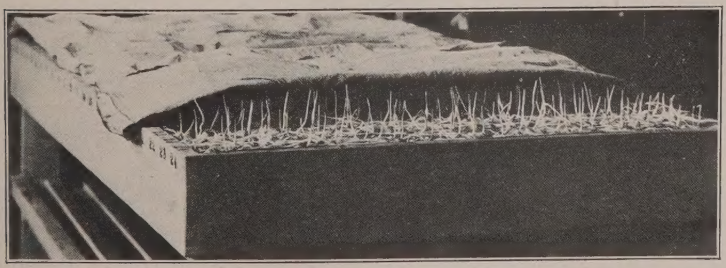
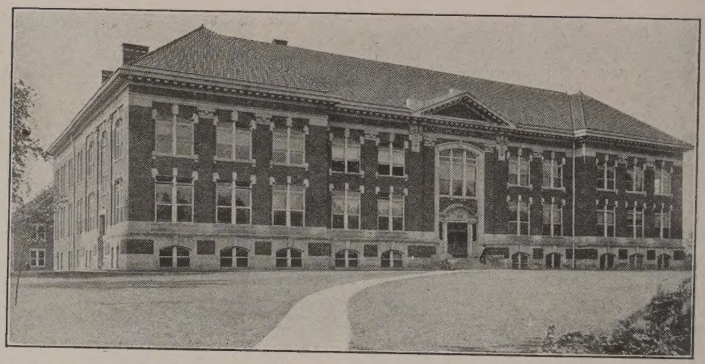


Fig. 20. Germination test completed. At this time infected seedlings can be noted and the diseased ears discarded



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Bulletin No. 213. The value of lime on Indiana soils
Bulletin No. 222. The value of manure on Indiana soils
Circular No. 25. (Revised edition) How to grow more and better corn
Circular No. 49. Farm manures
Circular No. 66. The lime and fertilizer needs of Indiana soils
Circular No. 76. Increasing crop yields for war needs
Circular No. 79. Indiana soils need phosphates

AGRICULTURAL EXPERIMENT STATION
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E. W. ALLEN,

Experiment Station Record